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# Patent Claims

1. Device with wireless transmission of a sound signal to a pair of headphones by means of a carrier, with the carrier being transmitted by a transmitter within the sound reproduction area and with the sound signal being modulated onto the carrier, characterized in such a way that two reception elements (6, 7) are attached to the pair of headphones with such directing effect and so configured that they afford directing characteristics which are at least close to that of human hearing, and that the reception elements (6,7) are connected to the headphone system (15, 16) by means of demodulators (10,11).

2. Device according to claim 1, characterized in such a way that the carrier is an ultrasound wave.

3. Device according to claim 1, characterized in such a way that the carrier is infrared light.

4. Device according to one of the above claims, characterized in such a way that during stereo reproduction within the reproduction area two transmitters are arranged at a distance from each other that is the usual distance between loudspeakers for stereo reproduction.

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Device with wireless transmission of a sound signal

During the reproduction of stereophonic recordings of sound events, the listener is able to imagine the position of the sound sources within the recording area. Here below, these positions will be called "imaginary positions," since during reproduction they only exist in the imagination. While the listener is able to "locate" one single sound source during reproduction through loudspeakers – by looking in the direction of the sound source's imaginary position – this is not possible during reproduction through headphones. The imaginary position turns together with the head. This irritates the listener. In addition, this quality is opposed to the natural inclination of humans to look into the direction of that sound source they are concentrating upon while listening.

The invention is based on the effort to eliminate the aforementioned disadvantage of headphone reproduction.

In the main patent...(patent application P 26 04 384.5), a possible solution for this problem is mentioned. This solution consists of a device with a headphone composed of two systems, with at least one adjusting element provided for the balancing of the sound tensions of the systems so that the imaginary position of the sound source reproduced in the headphone is changeable. This device is characterized in such a way that it includes a measuring element which measures the rotation of the head carrying the headphone in relation to a fixed hearing direction and creates an according steering tension, and that the adjusting element is steered by the steering tension in such a manner that the imaginary position of the sound source does not change, at least not significantly, when the head turns.

This invention – which creates an additional solution to the aforementioned problem – is based on a device with wireless transmission of a sound signal to a headphone by means of a carrier, with the carrier being transmitted by a transmitter within the sound reproduction area and with the sound signal being modulated onto the carrier. The invention is characterized by the feataures noted in patent claim 1.

In contrast to the main application, this invention does not provide an adjusting element in order to change the balance, yet the intensity of the wave coming from the transmitter, at the respective reception element, directly affects the signal reproduced in the headphone system. This is possible because there are separate signal passageways from the reception elements to the headphone systems.

An advantageous design of the invention described in claim 2, makes use of the fact that the human hearing apparatus also receives information about the direction from which a sound wave is coming, and the different phases in which sound waves reach both ears. Depending on the difference in the distances from the sound source in relation to the ear, travel time for the sound wave changes. Each direction has a specific travel time difference assigned to it, which results in a specific phase difference for a specific frequency. In order to identify the direction, the human brain is capable of analyzing this assignment of phase difference and direction within a certain frequency range. Parallel to this, and in other frequency ranges, the direction is recognized through differences in intensity of the sound waves received by the ear.

During reproduction through loudspeakers, the types of hearing directions here described are responsible for the determination of fixed imaginary positions. While during headphone reproduction the sound signal is usually simply transmitted to the headphone system instead of to a loudspeaker, this design of the invention with ultrasound waves as carrier replaces the loudspeaker by an ultrasound transmitter and, basically, a frequency transformer (reception elements, demodulator, headphone system) is interposed in front of each of the listener's ears, in order to adapt the human ear to the frequency of the ultrasound waves – which, of course, lie within the inaudible range.

Since the ultrasound waves possess the same travel speed as audible waves, orientation for direction by means of phase differences as described remains intact – as with reproduction through loudspeakers – if the directing qualities of the reception elements are at least close to those of the human ear.

The invention will be explained below with the help of the diagrams.

Diagram 1 shows a design example of the device according to the invention with ultrasound waves as the carrier, which are emitted from a single transmitter for the transmission of a mono-signal; and
Diagram 2 shows a corresponding device that transmits a stereo signal.

Diagram 1 depicts a headphone with headphone systems 15 and 16. Attached to the harness – which is not shown – are ultrasound reception elements 6 and 7. The directing characteristics of the reception elements and the position of the reception elements in relation to each other is chosen in such a way that the directing qualities of the arrangement equal – as closely as possible – the qualities of the human ear during medium and higher frequencies within the hearing range. The sound waves 5 of an ultrasound transmitter (diagram 1 above) positioned within the reproduction area can thus be received by the reception elements 6, 7 in the same way as the human ear receives sound waves within the appropriate range. The reception signals of the two reception elements 6 and 7 are amplified by means of connections in blocks 8 and 9 respectively, and cleared from interfering signals whose frequencies lie outside the frequency range to be transmitted. Subsequently, the signals are each demodulated in demodulators 10 and 11 respectively.

In certain frequency ranges, for instance within the range of lower frequencies, the human ear is not capable of distinguishing direction. This is taken into account by the fact that in block 12 the reception signals in these frequency ranges are mixed. The reception signals are then transmitted to the headphone systems 15 and 16 via amplifiers 13 and 14. The sound volume and the balance of reproduction as well as high/low pitch calibration can be carried out individually by means of manual calibration elements in the amplifiers 13 and 14.

An ultrasound transmitter whose carrier is modulated with a mono sound signal can be "heard" with the described headphone in such a way as if there were a loudspeaker positioned in the place of the transmitter which emits the signal to be transmitted within the audible sound range.

The transmitter shown in diagram 1 above includes a carrier frequency generator 4, a modulator 2, and an ultrasound transformer element 3. The low frequency signal to be transmitted to the headphone lies at the inlet 1 of the modulator. The modulator's inlet should be arranged in such a way that the exit socket of a low frequency amplifier can be connected directly. The modulator's exit 2 is connected to the ultrasound transformer 3.

In diagram 2, there are two transmitters for stereo sound transmission positioned within the reproduction area, while the transformer elements 17 and 18 of the two transmitters share such a spatial distance 23 from each other as is the normally usual one for loudspeakers during stereo reproduction. The two stereo sound signals lie at the entrances 21 and 22 of the modulators 19 and 20 of the transmitters. The carrier frequencies of the transmitters are the same. They are produced in a joint carrier frequency generator 4. The reception wiring corresponds to the wiring according to diagram 1. It is therefore only shown as a dotted box.

In order to avoid overlapping interferences of the ultrasound waves in space, different carrier frequencies can be used for the two channels, sufficiently separated within the frequency range as to not cause the modulation products to overlap. In this case, the reception wiring at the headphone must be arranged in such a way that the signals emitted by the two transmitters can be processed on both signal courses. In order to enable the listener to hear directions by means of phase differences, each ear has to be able to perceive both transmitters.

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Diagram 1